REMARKS

Claims 1-5 were pending in the application. In the Office Action mailed April 14, 2009, claims 1-5 are rejected. In the instant Amendment, claims 1-5 have been amended, and new claims 7-14 have been added. Upon entry of the instant Amendment, claims 1-5 and 7-14 will be pending in the application.

Claim 1 has been amended to recite that the surface layer of the steel product is subjected to ultrasonic impact treatment by impacting it at a plurality of different directions using one or more ultrasonic indenters. Support for the amendment to claim 1 is found in the specification as filed at p. 7, ll. 22-25 and Fig. 1.

Claim 2 has been amended to clarify that the ultrasonic impact treatment provides an amorphous state in said surface layer. Support for the amendment to claim 2 is found in the specification as filed at p. 7, ll. 1-5.

Support for new claim 7 is found in the specification at, e.g., p. 7, ll. 22-25. Support for new claim 8 can be found in the specification at p. 7, ll. 25-27. Support for new claim 9 is found in the specification at p. 8, ll. 20-23. Support for new claims 10-11 is found in the specification at p. 8, ll. 26-30. Support for new claim 12 is found in the specification at p. 8, l. 34 through p. 9, l. 7. Support for new claim 13 is found in the specification at p. 9, ll. 12-16. Support for new claim 14 is found in the specification at p. 7, ll. 11-17.

No new matter has been added by the amendment. Entry of the foregoing amendment and consideration of the following remarks are respectfully requested.

Rejections under 35 U.S.C. § 103(a)

Claims 1-5 are rejected under 35 U.S.C. 103(a) as being unpatentable over US Patent No. 6,338,765 ("US'765") in view of K. Lu, Nanocrystalline metals crystallized from amorphous solids: nanocrystallization, structure, and properties, Materials Science and Engineering, R16 (1996) pp. 161-221 ("Lu"), and X.Y. Wang and D.Y. Li, Mechanical and electrochemical behavior of nanocrystalline surface of 304 stainless steel, Electrochimic Acta, 47, (2002), pp. 3939-3947 ("Wang").

Independent claim 1 provides a method of producing a steel product having a nanocrystallized surface layer using ultrasonic impact treatment followed by heat treatment to cause precipitation of nanocrystals. Specifically, the ultrasonic impact treatment is conducted by impacting the surface of the steel at a plurality of different directions using one or more ultrasonic indenters, with said ultrasonic impact treatment of said surface layer providing equiaxial grains in said surface layer.

Exemplary plurality of directions is depicted in several embodiments. An embodiment is illustrated in Figure 1 and described at page 6, lines 8-12, which shows a plurality of directions exemplified by directions Z_1, Z_2, and Z_3. In this embodiment, the indenters are set at different angles with respect to the surface and therefore each impact the surface in a different direction. In the embodiment illustrated in Fig. 2, the indenters are arranged at angles of 120° from each other. Another embodiment is illustrated in Fig. 4 and described at the paragraph bridging pages 8 and 9, which shows a plurality of directions exemplified by directions Z4, (i.e., vertical) and Z5 (i.e., horizontal). In this embodiment, the indenters are simultaneously moved in the horizontal and vertical directions and therefore are able to impact the surface in different directions. The specification also states that "the angles of the plurality of vibration directions are not limited, but impact is applied from as different directions as possible." See, specification, at p. 7, ll. 22-25.

Also, the present specification discloses that the temperature of the ultrasonic impact treatment should be made sufficiently lower than the recrystallization temperature of the metallic material, and is preferably cold, with the heat generated by impact being removed by cooling. See, the specification at p. 7, ll. 6-21.

In contrast, US'765 teaches an ultrasonic treatment in which the indenter impacts the surface in one direction, e.g., the vertical direction, by conventional vibration, e.g. vibrating up and down. However, the present specification states that:

> [i]n working by impacting making ultrasonic indenters vibrate in only one direction, the structure of the surface layer of the metallic product is developed, the crystal grains do not become equiaxial, and the crystal grains deform to pancake shapes.

See, the specification, at page 6, ll. 15-19. Thus, the ultrasonic treatment of US'765 would be expected to have resulted in an undesired, pancake grain shape, and not have provided the claimed equiaxial microstructure.

Regarding the US'765 disclosure of "white layers," US'765 teaches that the formation of the white layers requires rapid heating at the point of impact to temperatures close to the steel annealing temperature, followed by rapid cooling similar to cooling after annealing (see, US'765 at col. 7, ll. 5-18). The US'765 patent further states that the above factors are achieved by regulation of the frequency and energy of impact and the magnitude of contact stress (see, US'765 at col. 7, ll. 19-20). There is no disclosure or suggestion of subjecting the surface of the steel to impacts at a plurality of different directions using one or more ultrasonic indenters. Furthermore, there is no disclosure that the "white layers" produced by the method of US'765 are nanocrystallized surface layers.

The Examiner cites Lu for teaching a basic principle for crystallizing ultrafine crystallites, in particular nanocrystals. Lu provides a general review of nanocrystalline metals crystallized from amorphous solids. However, only bulk properties are considered. There is no teaching in Lu of ultrasonic treatment of the surface of a steel, much less treating the surface of a steel with impacts at a plurality of different directions by ultrasonic indenters.

The Examiner cites Wang for teaching annealing a nanocrystalline layer formed by sandblasting at 350 °C for 60 minutes. However, Wang does not teach or suggest ultrasonic treatment of any kind, much less treating the surface of a steel with impacts at a plurality of different directions by ultrasonic indenters.

Since neither Lu nor Wang teach or suggest a method in which a steel surface is impacted in a plurality of directions by one or more ultrasonic indenters, neither of these references supplies what are missing in US'765.

Therefore, claims 1-5 are not obvious under 35 U.S.C. § 103(a) over US'765, Lu, and Wang, either individually or in combination.

It is submitted that in view of the present amendment and foregoing remarks, the application is now in condition for allowance. It is therefore respectfully requested that the application, as amended, be allowed and passed for issue.

Respectfully submitted,
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